**Radiative Processes in Planetary Atmospheres — Homework 1**
Due: September 17, 2003

**Problem 1.1 (30 points)**

*A black land surface with a temperature of 15 ° C emits radiation at all frequencies.*

a) *What would be the emitted radiances at 0.5 μm, 1200 $cm^{-1}$, and 35 GHz? Use appropriate Plank functions in the calculations.*

b) *What is the wavelength of the maximum intensity of the black body at 7000K temperature (use Wien's Displacement law)?*

**Problem 1.2 (30 points)**

*a) Ozone is a very important climatological parameter of the Earth atmosphere (see http://www.epa.gov/docs/ozone/science ).*
*Ozone amount is measured in Dobson units. A Dobson unit is a milli-atmospheric-cm, where an atm-cm is the thickness of the gas if reduced to standard temperature (273 K) and pressure (101.3 kPa). Total Ozone Column measured by Earth Probe TOMS over Antarctica on September 15 in 2001 during the so-called "Ozone Hole" event (at -71.00 Degrees Latitude -6.00 Degrees Longitude) is only 148 DU.*
*http://toms.gsfc.nasa.gov/ozone/ozone.html*
*Convert the total ozone in Dobson units to absorber amount in $g/cm^2$. Hint: a gas at standard temperature and pressure occupies 2.241 x $10^4$ $cm^3$/mol.*

*b) A radiosonde observation in Denver, Colorado on 16 February 2001 showed as much as 2.00 g/cm2 water vapor amount while the forecast was only for 0.15 g/cm2 of water vapor. Unpredicted dense fog caused the diversion of flights from Denver International airport for 18 hours. Usually water vapor is measured in precipitable cm or inches, which is the height of the column of water resulting from condensing all of the water vapor out. Convert 0.15 and 2.00 g/cm2 of water vapor to precipitable inches.*

*c) Carbon dioxide concentration is measured in parts per million by volume. There are small seasonal and geographic variations and an increasing trend. The maximum value in Texas as measured by the Climate Monitoring and Diagnostic Laboratory is about 390 ppmv (see http://www.cmdl.noaa.gov/ccgg/towers/diurnal.html). Convert this concentration to absorber amount in g/cm2 above Texas (457 m altitude, 990 mb pressure) and above the Mauna Loa observatory (3400 m altitude, 680 mb pressure).*

**Problem 1.3 (40 points).**

*Measurements by a narrow field of view tracking sun-photometer were done at Arosa, Switzerland (station is located at 0.8 atm pressure level). One morning the instrument records the following measurements at 0.38 μm wavelength as Sun rises above the horizon:*

| SZA (degrees) | Measurements from the instrument (*W/m2/mV*) |
|---|---|
| 50 | 616 |
| 40 | 760 |
| 30 | 873 |
| 20 | 1286 |

a) *What is the aerosol optical depth at 0.38 μm? Use Lambert-Beer law. Note, there is another source of attenuation at 0.38 μm wavelength besides aerosols, which is Rayleigh scattering by atmosphere. Rayleigh extinction coefficient at 380 nm is about 0.425 $atm^{-1}$ at sea level pressure (1 atm). If the instrument would be placed outside of the atmosphere it would measure 2275.6 W/m2/mV.*
b) *Did you need $V_0$ to solve for aerosol optical depth? Can you use another method? What assumptions about the atmosphere did you have to make to derive aerosol optical depth?*